

**U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE
ENERGY SUBCOMMITTEE**

HEARING CHARTER

Nuclear Fuel Reprocessing

**Thursday, June 16, 2005
10 a.m. – Noon
2318 Rayburn House Office Building**

1. Purpose

On Thursday, June 16, the Energy Subcommittee of the House Committee on Science will hold a hearing to examine the status of nuclear fuel reprocessing technologies in the United States.

Report language accompanying the House-passed H.R. 2419, the *Energy and Water Development Appropriations Act for Fiscal Year 2006*, directs the Department of Energy (DOE) to accelerate efforts to develop reprocessing technologies and to recommend a specific technology by September 2007.

The hearing will examine the status of reprocessing technologies and the impact reprocessing would have on energy efficiency, nuclear waste management and weapons proliferation.

2. Witnesses

Mr. Robert Shane Johnson is the Acting Director of the Office of Nuclear Energy, Science and Technology and the Deputy Director for Technology at the Department of Energy.

Dr. Phillip J. Finck is the Deputy Associate Laboratory Director, Applied Science and Technology and National Security at Argonne National Laboratory.

Dr. Roger Hagenruber serves at the University of New Mexico as Director of the Office for Policy, Security and Technology; Director of the Institute for Public Policy; and professor of political science. He also chairs the Nuclear Energy Study Group of the American Physical Society, which issued a May 2005 report, *Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risk*.

Mr. Matthew Bunn is a Senior Research Associate in the Project on Managing the Atom at Harvard University's John F. Kennedy School of Government.

3. Overarching Questions

- What are the advantages and disadvantages of nuclear reprocessing in terms of efficiency of fuel use, disposal of nuclear waste, and proliferation of nuclear weapons?
- What is the current state of reprocessing technologies? What criteria should be used to choose a technology? What do we still need to know to make this decision? Would choosing a reprocessing technology in 2007 limit future choices regarding other nuclear technologies, such as reactor designs?

4. Brief Overview

- Nuclear reactors generate about 20 percent of the electricity used in the U.S. No new nuclear plants have been ordered in the U.S. since 1973, but there is renewed interest in nuclear energy both because it could reduce U.S. dependence on foreign oil and because it produces no greenhouse gas emissions.
- One of the barriers to increased use of nuclear energy is concern about nuclear waste. Every nuclear power reactor produces approximately 20 tons of highly radioactive nuclear waste every year. Today, that waste is stored on-site at the nuclear reactors in water-filled cooling pools, or at some sites, after sufficient cooling, in dry casks above ground. About 50,000 metric tons of commercial spent fuel is being stored at 73 sites in 33 states. A recent report issued by the National Academy of Sciences concluded that this stored waste could be vulnerable to terrorist attacks.
- Under the current plan for long-term disposal of nuclear waste, the waste from around the country would be moved to a permanent repository at Yucca Mountain in Nevada, which is now scheduled to open around 2012. Yucca continues to be a subject of controversy. But even if it opened and functioned as planned, it would have only enough space to store the nuclear waste the U.S. is expected to generate by about 2010.
- Consequently, there is growing interest in finding ways to reduce the quantity of nuclear waste. A number of other nations, most notably France and Japan, “reprocess” their nuclear waste. Reprocessing involves separating out the various components of nuclear waste so that a portion of the waste can be recycled and used again as nuclear fuel (instead of disposing of all of it). In addition to reducing the quantity of nuclear waste, reprocessing allows nuclear fuel to be used more efficiently. With reprocessing, the same amount of nuclear fuel can generate more electricity because some components of it can be used as fuel more than once.

- The greatest drawback of reprocessing is that current reprocessing technologies produce weapons-grade plutonium (which is one of the components of the spent fuel). Any activity that increases the availability of plutonium increases the risk of nuclear weapons proliferation.
- Because of proliferation concerns, the U.S. decided in the 1970s not to engage in reprocessing. (The policy decision was reversed the following decade, but the U.S. still did not move toward reprocessing.) But the Department of Energy (DOE) has continued to fund research and development (R&D) on nuclear reprocessing technologies, including new technologies that their proponents claim would reduce the risk of proliferation from reprocessing.
- The report accompanying H.R. 2419, the *Energy and Water Development Appropriations Act for Fiscal Year 2006*, which the House passed in May, directed DOE to focus research in its Advanced Fuel Cycle Initiative program on improving nuclear reprocessing technologies. The report went on to state, “The Department shall accelerate this research in order to make a specific technology recommendation, not later than the end of fiscal year 2007, to the President and Congress on a particular reprocessing technology that should be implemented in the United States. In addition, the Department shall prepare an integrated spent fuel recycling plan for implementation beginning in fiscal year 2007, including recommendation of an advanced reprocessing technology and a competitive process to select one or more sites to develop integrated spent fuel recycling facilities.”
- During floor debate on H.R. 2419, the House defeated an amendment that would have cut funding for research on reprocessing. In arguing for the amendment, its sponsor, Mr. Markey, explicitly raised the risks of weapons proliferation. Specifically, the amendment would have cut funding for reprocessing activities and interim storage programs by \$15.5 million and shifted the funds to energy efficiency activities, effectively repudiating the report language. The amendment was defeated by a vote of 110-312.
- But nuclear reprocessing remains controversial, even within the scientific community. In May 2005, the American Physical Society (APS) Panel on Public Affairs, issued a report, *Nuclear Power and Proliferation Resistance: Securing Benefits, Limiting Risk*. APS, which is the leading organization of the nation’s physicists, is on record as strongly supporting nuclear power. But the APS report takes the opposite tack of the Appropriations report, stating, “There is no urgent need for the U.S. to initiate reprocessing or to develop additional national repositories. DOE programs should be aligned accordingly: shift the Advanced Fuel Cycle Initiative R&D away from an objective of laying the basis for a near-term reprocessing decision; increase support for proliferation-resistance R&D and technical support for institutional measures for the entire fuel cycle.”
- Technological as well as policy questions remain regarding reprocessing. It is not clear whether the new reprocessing technologies that DOE is funding will be

developed sufficiently by 2007 to allow the U.S. to select a technology to pursue. There is also debate about the extent to which new technologies can truly reduce the risks of proliferation.

- It is also unclear how selecting a reprocessing technology might relate to other pending technology decisions regarding nuclear energy. For example, the U.S. is in the midst of developing new designs for nuclear reactors under DOE's Generation IV program. Some of the potential new reactors would produce types of nuclear waste that could not be reprocessed using some of the technologies now being developed with DOE funding.
- Finally, the economics of nuclear reprocessing are unclear. (The Committee intends to examine the economic questions in a later hearing.) The U.S. nuclear industry has not been interested in moving to reprocessing because today it is cheaper to mine uranium and turn it into fresh fuel (through "uranium enrichment") than it is to reprocess and recycle spent fuel.

5. Background

Current U.S. Practice: The open fuel cycle

Current U.S. nuclear technology uses what is called an "open fuel cycle," also known as a "once-through cycle" because the nuclear fuel only goes through the reactor one time before disposal, leaving most of the energy content of the uranium ore unused. In an open cycle, the uranium is mined and processed, enriched, and packaged into fuel rods, which are then loaded into the reactor. In the reactor, some of the uranium atoms in the fuel undergo fission, or splitting, releasing energy in the form of heat, which in turn is used to generate electricity. Once the fission efficiency of the uranium fuel drops below a certain level, the fuel rods are removed from the reactor as spent fuel. Spent fuel contains 95 percent uranium by weight, 1 percent plutonium, with the remaining 4 percent consisting of fission products (Strontium, Cesium, Iodine, Technetium) and a class of elements known as actinides (Neptunium, Americium and Curium).

Actinides are a class of radioactive metals that are major contributors to the long-term radioactivity of nuclear waste. The fission products and actinides have half-lives¹ ranging from a few days to millions of years. The ongoing radioactivity of the spent fuel means that it still generates a lot of heat, so after removal, the spent fuel rods are cooled in deep, water-filled pools. After sufficient cooling, the fuel rods may be transferred to dry cask storage pending ultimate disposal at a geologic waste repository such as Yucca Mountain. Often they are just left in the cooling pools while awaiting disposal.

A recent National Academy of Sciences study examined the vulnerability of interim spent fuel storage to terrorist attack. After a dispute with the Nuclear Regulatory Commission, the Academy released a declassified version of the study in April, titled *Safety and*

¹ The "half-life" of a radioactive substance is the period of time required for one-half of a given quantity of that substance (e.g. plutonium) to decay either to another isotope of the same element, or to another element altogether. The substances with shorter half-lives tend to generate more heat.

*Security of Commercial Spent Nuclear Fuel Storage*². That report concluded that the pools, under certain conditions, could be vulnerable to attack, resulting in a large release of radioactivity, and recommended steps to reduce the risk of such an incident. Dry cask storage has inherent security advantages, according to the study, but can be used only after the fuel has cooled for at least five years in a water-filled pool.

If the licenses for most currently operational nuclear power plants are extended to allow a 60-year operational lifetime as anticipated, the U.S. will need to make a choice: increase the statutory storage capacity of Yucca, build a second repository, close the fuel cycle, or change the Nuclear Waste Policy Act to allow indefinite above-ground dry storage until another solution is found. Some suggest that such a decision is a necessary prerequisite to any expansion of the nuclear industry in this country, in large part because the public needs to be convinced that the U.S. has a long-term strategy for waste disposal. In addition, by law, the Nuclear Regulatory Commission must make a “waste confidence determination” – that the waste created can be safely disposed of – in order to continue issuing facility licenses.

Closing the fuel cycle: Reprocessing and Recycling

The “closed” fuel cycle requires the same mining, processing and fuel fabrication as the open cycle, prior to initial loading of the fresh fuel rods into the reactor. However, in the closed cycle, the cooled spent fuel is reprocessed, or separated into its individual components. In this approach, some components of the spent fuel can be used to fabricate new fuel for the reactor. The unusable waste is either safely encased and disposed of as is (which means it is still very hot and radioactive), or “burned” in a different type of reactor to reduce the heat and radioactivity and then disposed of. In theory, the fuel can go around this cycle many times until most of the energy content is converted into electricity and only unusable products remain for disposal.

Several countries around the world, including Japan, Russia and France, currently reprocess their spent fuel with a process known as PUREX, short for plutonium-uranium extraction, in which plutonium and uranium streams are isolated from the remaining waste products. The fission products and minor actinides are cooled and then vitrified, or encased in glass, for long-term disposal. The uranium separated through PUREX is impure and can’t be fabricated into fuel without further processing. As a result, the separated uranium is disposed of as low-level waste. The plutonium, on the other hand, can be mixed with freshly mined and enriched uranium to fabricate a mixed-oxide fuel known as MOX, which is recycled into reactors to generate more power. Plutonium can also be used to make weapons. Current practice in these countries is to reuse the plutonium only once and then dispose of the remaining waste rather than reprocessing and recycling a second time.

² Board on Radioactive Waste Management, National Research Council of the National Academies, *Safety and Security of Commercial Spent Nuclear Fuel Storage*, April 2005

The Advanced Fuel Cycle Initiative at DOE

The Administration's May 2001 National Energy Policy recommended that the United States "develop reprocessing and fuel treatment technologies that are cleaner, more efficient, less waste-intensive, and more proliferation-resistant." The Advanced Fuel Cycle Initiative (AFCI) in the Nuclear Energy, Science and Technology Office at DOE has existed in various forms for many years, but adjusted its mission in response to the President's call for a return to reprocessing. The primary goals of the AFCI program are to: "develop technologies that will reduce the cost of geologic disposal of high-level waste from spent nuclear fuel, enhancing the repository performance [and] develop reactor fuel and fuel cycle technologies to support Generation IV nuclear energy systems."

Scientists working on AFCI are developing at least two reprocessing technologies, UREX+ and pyroprocessing, while continuing research on a new generation of technologies. The Department claims that both UREX+ and pyroprocessing have the potential to reduce U.S. nuclear waste problems while effectively managing proliferation and safety concerns. In UREX+, plutonium is never extracted in a pure stream – it remains mixed with neptunium and americium, two long-lived actinides that may act as proliferation deterrents by making the plutonium too toxic to handle without special equipment. In pyroprocessing, also known as "electro-metallurgical" processing, spent fuel rods are mechanically chopped, and the fuel is electrically separated into constituent products. This isolates the uranium while leaving the plutonium and other actinides mixed together. UREX+ is closer technologically to PUREX and is better suited than pyroprocessing for reprocessing the spent fuel from the current type of U.S. nuclear reactors, known as light water reactors.

Optimizing the fuel cycle

Reprocessing is only one of several steps that could be used to address nuclear waste problems. After actinides are separated from the waste stream, they can be further processed – "burned" – through a process called "transmutation." Transmutation, which requires a different type of nuclear reactor (such as a "fast reactor"), can generate electricity while reducing the toxicity of the actinides. Transmutation reduces the temperature of the waste products (radioactive materials are literally hot). This is significant because disposal sites, such as Yucca Mountain, can be limited in terms of the heat content they can accept as well as in terms of volume. Transmutation technologies have not yet been developed for other components of the nuclear waste stream.

Unless the U.S. also put into use transmutation technologies, reprocessing might be of less use. Reprocessing could increase the efficiency of nuclear fuel use and reduce the volume of waste, but without transmutation, it could not reduce the temperature ("heat load") of the waste sufficiently to allow Yucca Mountain to store more years of byproducts from nuclear generation.

In addition to pursuing reprocessing technologies, DOE has a program to develop the next generation of nuclear plants, known as Generation IV reactor designs that would be more energy efficient, proliferation-resistant and safer than the current fleet of reactors. Once DOE settles on a particular Generation IV design, it intends to sponsor a demonstration project, known as the Next Generation Nuclear Plant (NGNP) in Idaho. The NGNP also has the potential to make more efficient use of recycled plutonium as well as the other actinides to produce more electricity, possibly reducing the need for separate transmutation facilities in the future. However, spent fuel from some of the kinds of reactors being considered for the NGNP might not be able to be reprocessed using UREX+.

6. Witness Questions

Mr. Johnson

- What are the advantages and disadvantages of using reprocessing to address efficiency of fuel use, waste management and non-proliferation? How would you assess the advantages and disadvantages, and how might the disadvantages be mitigated?
- What are the greatest technological hurdles in developing and commercializing advanced reprocessing technologies? Is it feasible for the government to select a technology by 2007?
- To what extent will the Department have to modify its plans in order to comply with the report language accompanying the House-passed fiscal year 2006 Energy and Water Appropriations bill?
- What reprocessing technologies are currently under consideration? Is there one particular technology that is considered more promising than others?
- How should technology and policy decisions about other components of the fuel cycle influence the selection of a reprocessing technology?

Dr. Finck

- What are the advantages and disadvantages of using reprocessing to address efficiency of fuel use, waste management and non-proliferation? How would you assess the advantages and disadvantages, and how might the disadvantages be mitigated?
- What are the greatest technological hurdles in developing and commercializing advanced reprocessing technologies? Is it feasible for the government to select a technology by 2007?
- What reprocessing technologies currently are being developed at Argonne or at other National Labs? What technical questions must be answered?

- What reprocessing technologies are still in the basic research stage, what advantages might they offer, and what is the estimated timeline for development of laboratory-scale models?
- How would you contrast what is being done internationally with U.S. plans for reprocessing, recycling and associated waste management? What countries recycle now? What components of the waste fuel are or can be used to make new reactor fuel?

Dr. Hagengruber

- What are the advantages and disadvantages of using reprocessing to address efficiency of fuel use, waste management and non-proliferation? How would you assess the advantages and disadvantages, and how might the disadvantages be mitigated?
- What are the greatest technological hurdles in developing and commercializing advanced reprocessing technologies? Is it feasible for the government to select a technology by 2007?
- What kinds of research and development should the Department of Energy fund to ensure the proliferation resistance of future reprocessing technologies?

Mr. Bunn

- What are the advantages and disadvantages of using reprocessing to address efficiency of fuel use, waste management and non-proliferation? How would you assess the advantages and disadvantages, and how might the disadvantages be mitigated?
- What are the greatest technological hurdles in developing and commercializing advanced reprocessing technologies? Is it feasible for the government to select a technology by 2007?
- How should technology and policy decisions about other components of the fuel cycle influence the selection of a reprocessing technology? From your perspective, is the Department of Energy conducting the systems analysis required to make sound near-term technology decisions and guide long-term research and development?